PERIODICAL U. of So. Africa Investig. Report
No. 18
#18

UNION OF SOUTH AFRICA

JUN 1955
LIBRARY
FOR
FISH & WILDLIFE
SERVICE

DEPARTMENT OF COMMERCE AND INDUSTRIES

DIVISION OF FISHERIES

INVESTIGATIONAL REPORT No. 18

THE SOUTH AFRICAN PILCHARD

(Sardinops ocellata)

BIRD PREDATORS, 1953-4

BY

D. H. DAVIES, M.Sc.

(Senior Professional Officer)

THE GOVERNMENT PRINTER, PRETORIA

1955

G.P.-S.112090—1954-5—800.

Reprint from "Commerce & Industry". JANUARY, 1955

DEPARTMENT OF COMMERCE AND INDUSTRIES

DIVISION OF FISHERIES

INVESTIGATIONAL REPORT No. 18

THE SOUTH AFRICAN PILCHARD

(Sardinops ocellata)

BIRD PREDATORS, 1953-4

BY

D. H. DAVIES, M.Sc.

(Senior Professional Officer)

Contents.

	PAGE
1. Summary	3
2. Introduction	3
3. Problem	5
4. Area	5
5. Method	5
(i) General	5
(ii) Procedure	6
(iii) Assessment of Results	7
(iv) Presentation of Results	7
6. The Fish-eating Birds of St. Helena Bay	8
7. The Cape Gannet	8
(i) General	8
(ii) Method of Feeding	9
(iii) The Food of the Gannet	10
(iv) Temperature	13
(v) Discussion	15
8. The Cape Cormorant	15
(i) General	15
(ii) Method of Feeding	16
(iii) The Food of the Cormorant	17
(iv) Temperature	19
(v) Discussion	19
9. The Cape Penguin	21
(i) General	21
(ii) Method of Feeding	22
(iii) The Food of the Penguin	22
(iv) Temperature	24
(v) Discussion	24
10. General Discussion	24
11. Recommendations	28
12. Acknowledgments	28
13. References	29

1. SUMMARY.

This paper is the fourth of a series concerned with the general biology of the South African pilchard *Sardinops ocellata* (Pappe), and deals with the predation of the pilchard by sea-birds.

Feeding studies on the fish-eating birds of the St. Helena Bay area off the west coast of the Union of South Africa were made. Of the eleven species investigated, three are considered to be important predators of commercial species of fish, particulary of the pilchard. These birds are as follows:—

A. The Cape Gannet, *Morus capensis.*
B. The Cape Cormorant, *Phalacrocorax capensis*
C. The Cape Penguin, *Spheniscus demersus.*

The method of feeding is described for each of these species.

Based on the examination of the stomachs of 98 birds over a period of a year, the food of the gannet in the St. Helena Bay area was found to consist entirely of fish of the following species: Pilchard (*Sardinops ocellata*), Horse Mackerel or Maasbanker (*Trachurus trachurus*), Anchovy (*Engraulis japonicus*), Mackerel (*Scomber japonicus*) and Mullet or Harder (*Liza ramada*).

The population of gannets feeding in the St. Helena Bay area is estimated at 200,000 birds, which eat a total of 73,000 tons of fish per year of which 37,000 tons consist of pilchards and 12,000 tons of maasbankers. These amounts represent about one quarter and one seventh respectively of the total commercial catches of these two species landed in the Union for the year 1953. These figures are based to a certain extent on estimate, and thus should be regarded as tentative, and subject to alteration in relation to further research.

Based on the examination of the stomachs of 37 birds, the food of the cormorant in the St. Helena Bay area was found to consist of the following: Pilchard (*Sardinops ocellata*), Maasbanker (*Trachurus trachurus*), Anchovy (*Engraulis japonicus*), *Paralepis* sp. and Cape Rock Lobster (*Jasus lalandii*).

The population of Cape cormorants feeding in the St. Helena Bay area is estimated at 30,000 birds, which eat a total of 3,660 tons of fish per year, of which 1,800 tons consist of pilchards and 550 tons of maasbankers. These figures represent about one eightieth and one one hundred and seventieth respectively of the total commercial catches of these two species in the Union for the year 1953. It is pointed out that these figures are partly based on estimate and must be regarded as tentative.

Based on the examination of the stomachs of 17 birds, the food of the penguin in the St. Helena Bay area was found to consist of the following: Pilchard (*Sardinops ocellata*), Maasbanker (*Trachurus trachurus*), Anchovy (*Engraulis japonicus*), Mackerel (*Scomber japonicus*), Harder (*Liza ramada*), and Cape Rock Lobster (*Jasus lalandii*).

No information on the population of penguins is available.

Notes on the feeding of eight other species of sea-birds are given.

2. INTRODUCTION.

The South African pilchard *Sardinops ocellata* (Pappe) is well known as a species of considerable commercial importance to South Africa. A programme of research was started in 1950 to find out the general biology and ecology of the fish for purposes of the conservation of the resource. Apart from research directly related to the pilchard in all stages of its life, considerable importance was attached to studies of an indirect yet equally important nature such as environment, associated fauna and predators. This report is a consideration of the preliminary findings in relation to one group of predators—the birds.

The pilchard has many predators, including fish such as snoek (*Thyrsites atun*), mammals such as seals and man, and birds. At this stage it is difficult to assess which predator does the most damage. There is no doubt that when snoek are present in the area they take a heavy toll of pilchards, but they are usually in the vicinity of St. Helena Bay for only 2–3 months of the year. Stockfish (*Merluccius capensis*) have also been found to eat pilchards but as stockfish spend the greater part of their lives in the deeper off-shore waters of the trawling grounds, it is unlikely that they consume very large numbers of pilchards. Seals have been seen actively feeding on pilchard shoals, but few actual feeding records are available. In Union waters man preys upon the pilchard to the extent of approximately 150,000 tons per year, caught in the area of St. Helena Bay alone. Little else was known about the sea-birds of this area other than the fact that certain species do eat pilchards. In spite of this, however, a great deal has been said from time to time about the predation of sea-birds on fish of commercial importance.

The following notice appeared recently in the *Cape Argus* (1953):—

" Sen. S. M. Pettersen (Ind: Natal), who is a Durban ship's chandler, will ask the Minister of

Economic Affairs (Mr. E. H. Louw) on August 20 whether he will end the protection of sea-birds and seals in Union waters.

He wants Mr. Louw to consider introducing a Bill granting permission, under Government control, for the collection of all eggs of penguins, *malgas* and *duikers*, and for the subsequent destruction of these birds."

This representation was received coolly by the Minister and raised a storm of protest from various local bodies interested in the protection of bird life, but at the same time it received a considerable amount of support from other directions. Unfortunately no facts of any sort were available to those who supported this idea and although many examples of policy in relation to sea-birds in other countries were cited, none could really be applied to our own conditions without a basis of extensive research. Among other claims, it was stated that the cormorant, gannet and penguin kill for the lust of killing even after their voracious appetites have been satisfied. It is not known what basis there was for such a statement, because it is evident, after more than four years of personal observation, that each of these birds has a definite limit in the numbers of fish it can consume at any one time. This may be regarded as a " meal " and is probably equivalent to the cubic capacity of the stomach and oesophagus of the species. Once the bird has had a full meal it shows no further interest in catching fish until it has made room for more by digestion. At no time has any bird been seen catching fish and making no further use of them.

There is no doubt that the sea-birds and seals are the scapegoats of the fishermen. When there is a scarcity of fish or a diminution in catch at any time there is nearly always an outcry against the birds or the seals. It is natural, of course, to look for someone to blame in time of crisis and the birds are there in large numbers for everyone to see and they cannot answer back. This does not mean that they are not to blame for their depredations on fish, but it does create a strong prejudice against them which is not based on any scientific findings.

In June 1954 the following motion was made in the Senate by Senator Petterson:—

" That in view of the serious depredations carried out by certain birds and animals on the food sources of the Union both on land and in the seas around our coasts, this House urgently requests the Government to introduce legislation for the control of these pests by authorized persons."

Sen. Pettersen spoke on this subject in considerable detail, after which there followed a lengthy discussion by the Senate and a full reply by the Minister of Economic Affairs. The final result was an amendment of the original motion as follows:—

" That this House requests the Government to investigate the effect on sea-food sources of various fish-eating birds and animals and to consider whether steps should be taken to destroy such birds and animals."

This amendment received the full support of Sen. Pettersen and was carried unopposed.

The significance of this amendment was considerable. The possibility of legislation for the immediate control and perhaps destruction of predatory birds and animals was thereby postponed and full investigations into predator-prey relationships, involving sea-food resources, were recommended in order to establish whether it was necessary to take any action against these predators.

It is fortunate, therefore, that the study of the pilchard has led to an increased knowledge, however small, of the sea-birds of the West coast and it is hoped that from this nucleus a full understanding of the birds and their ecological relationships with the other fauna of the area will be attained.

Certain sea-birds such as gannets, cormorants and penguins live in the West coast region in very large numbers. They breed on the rocky islands of the area where large deposits of guano accumulate. The birds and the islands on which they breed are administered and controlled by the Guano Islands Division of the Department of Commerce and Industries. On an average, a total of 5,500 tons of guano is collected every year from the islands off the coasts of the Union and South West Africa. Of this amount about 940 tons are deposited on the islands in the vicinity of St. Helena Bay, viz. Penguin Islet (Lambert's Bay) and Malagas, Marcus and Jutten Islands in Saldanha Bay. The total guano collection together with approximately 150,000 penguin eggs are sold annually.

The birds responsible for this production of guano and eggs are given complete protection by law. Special permission was granted by the Superintendent of Guano Islands for the Division of Fisheries to shoot guano producing birds for research purposes.

3. PROBLEM.

Since all that was known was that certain sea-birds of the West coast region were said to eat pilchards in large numbers, the problem was first of all to establish which species actively fed on pilchards, and, having discovered this, to find out to what extent.

Thereafter, a means of taking regular samples of feeding birds of the species concerned had to be evolved on a basis which would show seasonal variation. This was by no means easy, and in practice so many contingencies arose that it was evident that work on the same lines over a period of years was the only means whereby anything like a full picture of the feeding habits of the birds could be obtained.

4. AREA.

The main commercial pilchard fishing grounds of the Union of South Africa lie off the West coast and are centred in St. Helena Bay. Most of the catches are made in the area of sea bounded by Cape Columbine in the south, Rooiduinepunt in the north and extending 35 miles seawards from a point midway between the two (see Fig. 1). At times considerable quantities of pilchards are caught south of Cape Columbine and in Saldanha Bay itself, although their occurrence in this area is irregular.

A number of stations, drawn up to cover the area of St. Helena Bay from the point of view of pilchard research, was worked once a month by one of the two small vessels of the Division of Fisheries, R.V. *Schipa* and P.B. *Palinurus*. The former is a modified ex-naval rescue launch of total length 108 feet with a cruising speed of 12 knots, and the latter a patrol boat, designed as a fishing boat, 50 feet in length with a cruising speed of 9 knots.

During the normal round of stations during which the work consisted mainly of the collection of plankton, temperature and meteorological data, feeding sea-birds were shot and retained for stomach content examination. It was seldom possible to send either of these vessels on special missions for the collection of birds, and this work had to be done incidentally to the main pilchard research. For this reason there were often unavoidable breaks in the continuity of the collection of the data. The data obtained is nevertheless of much interest and considerable significance.

5. METHOD.

(i) General.

Before describing the method used, some mention of the assessment of the food of birds in general is given. Due to the fact that so many techniques are used in the evaluation of organisms eaten by birds, and more particularly because each depends on a special set of circumstances, one method on its own is seldom sufficient to provide adequate data. Hartley (1948) states in his discussion on the various methods of assessing food of birds that, after more than 50 years of work on the feeding of wild birds, our knowledge remains almost entirely qualitative. This statement is without doubt a true representation in spite of the numerous attempts at quantitative estimation of bird feeding which have been made.

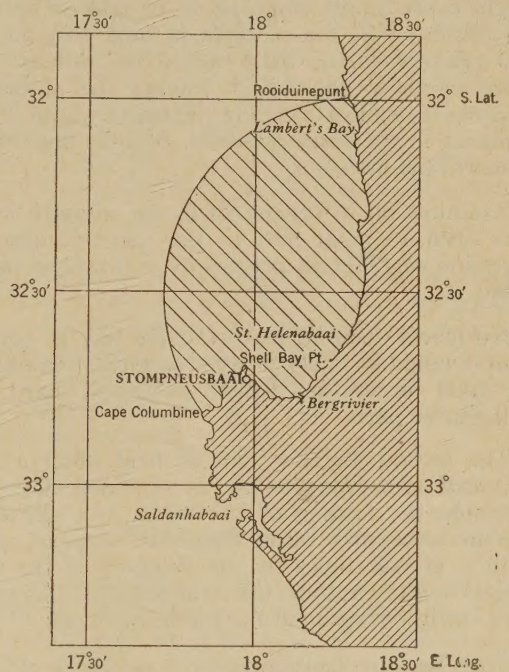


FIG. 1

MAIN COMMERCIAL FISHING GROUNDS

Trigsurvey, 1954. Government Printer, 1954.

There is no doubt that the establishment of a true picture of the feeding habits of any animal is no easy matter, and depends on a large number of factors which are peculiar to both the species and its prey. Further, food studies have more recently been undertaken not only from an academic point of view but as a matter of urgency in order to discover the economic status of a species. It is therefore not only desirable, but essential, to devise

a means of assessing the feeding habits of the bird in order that a complete and correct picture may be formed of its normal behaviour in relation to the entire ecological complex of its environment.

The feeding habits of sea-birds may be studied by the examination of the contents of the alimentary tract, and by actual observation and record of the bird eating its food. The former method is the one most widely used and may be confined to an examination of the stomach alone, or the stomach together with the rest of the gut, including the contents of the rectum and faeces. It was decided to confine operations to a detailed examination of the oesophagus and stomach because of the fact that the only parts of the food organism which remain after having passed through the stomach are the hard parts, e.g. otoliths and scales of fishes; too much attention paid to these in the intestine might cause undue emphasis to be laid on certain organisms. If, for example, a bird were to eat 500 pilchard larvae there would be little or not trace of these soon after leaving the stomach, whereas a meal of 5 young pilchards would leave evidence in the form of scales, otoliths and small bones in the intestine.

Examination of organisms in the stomach itself was open to error due to the varying rates of digestion of different organisms or parts of organisms.

No faecal material was available but its examination would be likely to lay even greater emphasis on food organisms which possessed hard or indigestible parts.

The second method, that of field observation, was used whenever possible, as an added means of assessing the feeding of the birds, and although this amounted to a rather disjointed series of notes written at odd times by the skippers of the two vessels and the author, the data collected formed a very useful background for the whole work.

Very serious consideration was given to the question of sampling. In the first place, it was often found difficult or impossible to collect more than a few birds during a whole month and sometimes a particular species was not represented at all. This was due to many factors such as the disappearance of the birds from the area, bad weather, lack of time and opportunity, etc. It may be said, however, that every attempt was made to collect as many birds as possible during each month.

It was originally decided to shoot sea-birds at all times, whether they were actually feeding or not. This practice was discontinued at an early stage, however, due to the fact that birds sitting on the water or flying were generally found to have empty stomachs. This was considered to be a serious waste of bird material and thereafter only birds in the act of either catching food organisms or eating them were shot. In this way the majority of bird stomachs examined were found to contain food material.

(ii) Procedure.

The procedure adopted for the collection of stomach contents of sea-birds was as follows:—

During the period in each month in which the small vessel was operating in St. Helena Bay, the skipper had instructions to shoot feeding sea-birds whenever possible, i.e. in the course of his normal duties when working the inshore stations of the pilchard research programme. This was found to produce too small a number of birds in a month and further instructions were given that a small unspecified number of feeding birds had to be shot each month as a part of the pilchard research programme. This was again increased at a later date to a minimum of 10 birds of each species per month, and it was only towards the end of the year under review that really satisfactory numbers of birds were coming in.

When the small vessel encountered a large number of actively feeding birds, two of each species present were shot, the temperature of the water taken, the time noted and the position worked out in latitude and longitude. Sometimes the bird was not immediately killed and regurgitated part or all of its stomach contents before being retrieved. In this case a note was made by the skipper as to how many fish etc. had been lost, but due to accurate shooting death was usually instantaneous and none of the stomach contents was lost. The stomach (including oesophagus cut just below the head) was then carefully removed from each bird, and a half-inch slit cut in it to allow immediate penetration of preserving fluid It was then placed in a jar with 10 per cent. neutral formalin solution together with the head of the bird. A label giving full particulars was included and the jar and contents transported to the shore biologist at the field station at Stompneus or to the headquarters laboratories at Sea Point. The reason for the inclusion of the head of the bird in the jar in each case was to ensure that it was properly identified by a fully-qualified person. The oesophagus as well as the stomach was included because it frequently occurred that a bird which had fed particularly well had a fully packed

stomach which had " overflowed " upwards into its oesophagus

When the sample reached the biologist, the bird was identified by examination of the head and the stomach was removed and placed in a flat dish. It was then opened by means of a single longitudinal cut and the contents carefully taken out in such a manner that semi-digested organisms were not disrupted. Each organism was then identified as far as possible, weighed, and its total length measured. In the case of an organism in an advanced state of digestion every attempt was made to identify it by carefully floating it out in water in a petri dish. Detailed notes were made concerning the state of digestion of the various organisms, together with any other observations which might be of assistance in assessing the feeding of the bird.

(iii) Assessment of Results.

Apart from a general statement that a particular bird eats a certain species of fish, i.e. a purely qualitative indication of something it has been found to eat, which on its own is of interest but of little value, there are three ways in which the feeding of birds may be assessed. These are the numerical, gravimetric and volumetric methods.

The numerical method consists of a simple statement of each food organism found in the stomach of the bird, or the enumeration of its frequency of occurrence, i.e. a statement of the number of birds in which each particular food organism was found, or a combination of both the enumeration of the food and its frequency of occurrence.

This method has the advantage that the varying state of digestion of the food organisms is not taken into consideration, but is unsatisfactory with food organisms which cannot be separated into individuals, e.g. the " pulp " formed when large numbers of larval fish have been eaten and a certain amount of digestion has taken place. Another serious disadvantage of this method is that the different sizes of various organisms are not taken into account.

The gravimetric method consists of the separation and weighing of the different organisms found in the stomach. Although not a very effective method when used alone, it gives very good results when used in conjunction with the numerical method. In the weighing method it is necessary to separate the different food organisms and this sometimes presents difficulties. Another difficulty is that the weight of an organism is affected by its state of digestion. Fortunately, however, numerous data on the length/weight relationship of pilchards, maasbankers and anchovies were available. Where it was possible to measure the total length of the fish obtained from the stomach, a mean weight for that length could be looked up and compared with the actual weight of the partly digested fish. From this, an estimated weight was worked out wherever possible and a reasonably accurate representation obtained of the quantities of these three species in stomachs.

The volumetric method, that of obtaining the volume of food organisms either directly or by displacement of water, was found to be impracticable. Although food in any form could be measured by this means it was found extremely difficult to obtain the volume of, for example, a fish in an advanced state of digestion, due to disintegration and floating of particles when placed in water for the volume determination. It was also found difficult to interpret results in terms of volume.

In this work a combination of the numerical and gravimetric methods was used in conjunction with available data on length/weight relationships of such fish as pilchards, maasbankers and anchovies. It is felt that this combination provided the best method for giving a true reflection of the feeding of the birds.

(iv) Presentation of Results.

In the presentation of the results it is not possible to publish full details of every bird examined, but a summary is given in the form of a table for each species of bird. The summary is based on the enumeration of stomach contents and on a combination of the numerical and gravimetric methods. Together with weight data, total lengths of food organisms are given, a combination of these giving a definite indication of the size of the organism eaten. Particular care was devoted to the estimation of the total weights of organisms comprising stomach contents at the time of eating. In this way a more accurate idea of the amount eaten at one time, i.e. a " meal ", could be obtained than from the total weight of the stomach contents as a whole. In the remarks column an indication of the mean state of digestion of the food organisms is given.

6. THE FISH-EATING BIRDS OF ST. HELENA BAY.

During the course of pilchard research work in St. Helena Bay, observations on all sea-birds were made. It is considered that the following species are important as fish-eaters:—

A. Cape Gannet, *Morus capensis.*

B. Cape Cormorant, *Phalacrocorax capensis.*

C. Cape Penguin, *Spheniscus demersus.*

These three species were regularly seen in large numbers actively engaged in the catching and eating of fish. A common sight in St. Helena Bay was that of a pilchard shoal moving across the bay near the surface, attended by hundreds of birds—gannets on the wing flying up and down and diving at short intervals to bring up glistening fish, cormorants swimming in company with penguins in and round the shoal, each ducking under the water every now and then and coming to the surface as they swallowed a fish, and one or two terns and mollymawks also in attendance.

The following birds are common in the area but although sometimes present in large numbers, are never as numerous as the three species mentioned above. They have all been seen to eat fish but are considered to be of little importance as predators of commercial species:—

(i) White-breasted Cormorant, *Phalacrocorax carbo lucidus.*

(ii) Bank Cormorant, *Phalacrocorax neglectus.*

(iii) Crowned Cormorant, *Phalacrocorax africanus coronatus.*

(iv) Mollymawk, *Diomedia melanophris.*

(v) Dominican Gull, *Larus dominicanus.*

(vi) Hartlaub's Gull, *Larus hartlaubii.*

(vii) Common Tern, *Sterna hirundo.*

(viii) Arctic Tern, *Sterna macroura.*

The white-breasted cormorant was frequently seen catching and eating harders (*Mugilidae*) close inshore near sandy beaches, but was nowhere very common. The bank cormorant showed a preference for rocky inlets and bays and fed on klipfish (*Clinidae*) and young Cape rock lobster (*Jasus lalandii*). Few feeding records were obtained for the crowned cormorant. Neither this species nor the bank cormorant was common.

The mollymawk or black-browed albatross was common in St. Helena Bay but large aggregations were never seen. Mollymawks were frequently seen on the outskirts of pilchard shoals actively catching and eating fish. They were more numerous offshore in the vicinity of the trawling grounds where they fed on offal from the trawlers. Those seen from R.S. *Africana II* during the day appeared to feed mainly as scavengers, eating any floating material which happened to come their way. It is likely, however, that these and other albatrosses feed mainly at night when large numbers of organisms are near the surface, and, as already mentioned, there is no doubt about the mollymawk's ability to catch fish.

The gulls of both species appeared to spend all their time close inshore in the immediate vicinity of the factories where they behaved as scavengers, feeding on fish offal. The Dominican gull was far more numerous than Hartlaub's, but neither was seen catching live fish.

Both the common tern and the arctic tern are listed because of the difficulty of distinguishing the two species in the field. Both were known to be present and their feeding habits were apparently identical, namely flying, hovering, and then dipping at the surface of the sea. Their food appeared to consist largely of *Euphausiids* but on one occasion fish larvae were found in the stomach of a common tern.

7. THE CAPE GANNET.

(i) General.

The Cape gannet is widely distributed round the coast of Southern Africa from Angola to Zanzibar, the largest populations being found on the West coast of the Union and South West Africa, particularly in the St. Helena Bay and Walvis Bay areas. Much has been done in recent years to advance the study of the migration of the gannet by means of extensive ringing carried out mainly by Broekhuysen and Liversidge of the University of Cape Town and Rand of the Guano Islands Division. Their ring returns have shown that the largest migrations are apparently undertaken by young birds in the first two or three years of their lives.

The Cape gannet breeds during the spring and summer from September through to February, the months of main activity being October and November. Nesting takes place on the small, rocky, desolate islands off the coast such as Bird Island (Port Elizabeth), Malagas Island (Saldanhabaai), Penguin Islet (Lambert's Bay), and other islands farther up the West coast such as Possession, Ichaboe and Mercury. Each pair of nesting birds has its own nest of hard material, probably mud and guano, and a single egg is laid which requires

approximately six weeks of incubation. The single chick is fed by both parents for about three months, after which it is abandoned. When the young gannet leaves the nest it starves for a period of a week or more and then takes to the sea where it remains until feeding and flying activities are possible.

The gannet may be regarded as a coastal species which does not normally fly inland, and it generally remains within 30 miles of the shore. Groups of gannets have, however, been recorded over 50 miles from the shore on occasions. The average weight of the gannet is approximately 4½ lb.

Fig. 2.—The Cape Gannet (*Morus capensis*).

[*Photo : G. J. Broekhuysen.*

(ii) Method of Feeding.

From many observations at sea off the West coast it was established that the feeding activities of the gannet are carried out on a definite pattern. Methodical search flights are undertaken during the daylight hours by loose groups consisting of small numbers or solitary individuals. Greater activity in this direction is shown during the early morning. When a fish is spotted near the surface the bird stops its flight abruptly, sometimes hovering for a few seconds apparently to take aim, and then plummets down in a vertical or slanting dive with wings shut, often from a considerable height, hitting the water with a splash and reappearing at the surface within a few seconds in the final act of swallowing the fish.

As soon as a shoal of fish is located, however, large numbers of gannets rapidly appear and commence a systematic bombardment which at times lasts many hours and is often only halted by nightfall. Although it was difficult to observe single individuals for any length of time, the following operations appear to be typical of all gannets feeding on shoal-fish. The bird dives, catches a fish, comes to the surface having finished swallowing its prey, and rests on the water for a short period, at the same time drinking, ducking its head under the water and generally cleaning itself and shaking its feathers. Sometimes gannets come to the surface and fly off immediately without cleaning their feathers etc. This probably takes place when the dive is unsuccessful. Then it makes a noisy take-off, circles round and holds

itself in readiness for another dive as soon as it spots a fish.

One bird was seen to repeat this operation as many as five times in succession, after which it remained on the water a short distance from the shoal, preening its feathers and resting. This bird was shot and found to have eaten five large pilchards which completely filled its stomach and oesophagus.

Birds which have eaten a full meal probably rest on the water until digestion has become well advanced, when they begin fishing operations again. Gorged birds sitting on the water experience great difficulty in becoming airborne and if alarmed will regurgitate stomach contents vigorously before taking off. For this reason it is likely that the amount of fish taken from the feeding grounds to the nests during the breeding season by individual birds is less than a full meal and is probably restricted so that the bird can carry out the journey without difficulty.

During the breeding season birds were seen to catch a number of fish (e.g. 2–3 large pilchards) and then fly off in the direction of the islands where their catch was made available to their young by means of regurgitation. This movement back to the islands took place to a certain extent at all times, and young birds seemed to be more inclined to return there after a meal than to remain in the vicinity of fishing operations resting on the water.

It was found that the presence of large numbers of gannets in an area was a sure indication of the presence of shoal-fish such as pilchards, maasbankers or anchovies, and conversely when gannets were not seen in an area, shoal-fish were invariably absent.

(iii) The Food of the Gannet.

Feeding gannets were shot during every month of the year. The results below are considered to give a good indication of the food of this species off the West coast.

The food of the gannet was found to consist entirely of the following:—

(*a*) Pilchard, *Sardinops ocellata* (Pappe).
(*b*) Maasbanker, *Trachurus trachurus* Linn.
(*c*) Anchovy, *Engraulis japonicus* (Houttuyn).
(*d*) Mackerel, *Scomber japonicus* Houttuyn.
(*e*) Harder, *Liza ramada* (Risso).
(*f*) Fish remains, unrecognisable.

(*a*) *Pilchard.*—Pilchards were found to make up nearly one half of the total food of the gannet on a basis of frequency alone, and they comprised more than half when the estimated total weight of the organism at the time of eating was taken into consideration (see Fig. 6).

In general, pilchards were not found mixed with other species of fish in the bird stomachs, but occasionally were mixed with maasbankers and anchovies. The pilchards varied in number and size, and one stomach was found to contain 6 recently-eaten pilchards of mean total length 24 cm, representing an estimated total weight at the time of eating of approximately 1,200 gm (approx. $2\frac{3}{4}$ lb). This was probably very near the maximum possible total intake of an adult gannet at any one time, i.e. a full meal, and was consequently of considerable importance as an index of the total capacity of the of the species in terms of organisms normally eaten.

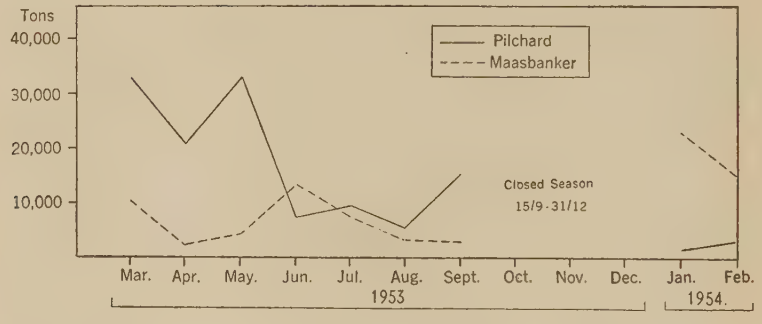


FIG.3

PILCHARD AND MAASBANKER COMMERCIAL CATCH RETURNS 1953-54.

Trigsurvey, 1954. Government Printer, 1954.

The size of pilchards eaten varied with the time of the year, but during most months, fish typical of the sizes in the commercial catch were eaten, i.e. fish of approximate mean total length 25 cm. During the summer months, however, when the adult fish were absent from the area, large numbers of juvenile pilchards in the groups of total lengths 5–10 cm were eaten.

Pilchards were eaten during all seasons of the year—adult fish in autumn, winter and spring and juveniles in summer. Adult pilchards were not, however, found to have been eaten during the months of November to March, no doubt due to the fact that they were not available in the area. Juvenile pilchards were eaten in December and February.

From the time of the start of the migration of adult pilchards in October until the time of their gradual re-appearance in March, the numbers of gannets seen in the area declined, reaching a minimum in November and early December and then increasing after the arrival of the juvenile pilchards. The decrease in the number of gannets may also have been connected with their own reproductive activities.

During February, however, Liversidge (private communication) recorded gannets as having eaten large numbers of adult pilchards, as shown by regurgitated stomach contents of birds caught for ringing at Malagas Island in Saldanhabaai. These were probably the early arrivals of the commercial shoals.

Note on the Gannet in Natal.

During the month of June, 1954, large numbers of gannets were seen off the coast of Natal actively feeding on pilchards migrating northwards. Although the birds were frequently seen to be flying or feeding in small groups of 25–30, larger groups estimated at five thousand or more were also present, and during the period when pilchards were moving past the coast they moved along with them. An estimate of the total number of gannets present off the Natal coast at this time would be difficult if not impossible, but there is no doubt that very large numbers carry out this feeding migration every year.

Although it is likely that many of these gannets come from the nearest breeding place, viz. Bird Island near Port Elizabeth, ringing returns have shown that birds from the West coast have been found off the East coast. It is therefore possible that the East coast migrants may have among them individuals from as far away as the West coast.

Although June and the two preceding months are normally good fishing months for pilchards in St. Helena Bay, it appears that gannets from this area may move away on an extended feeding migration up the coast of Natal as far as Durban. It would be of great interest to know if this migration is started from St. Helena Bay. The study of the movement of the gannets may well be an indication of importance in the study of the migration of the pilchard.

It is of interest to note that about one quarter of all the gannets seen off Natal were not fully adult, their plumage being completely or partially dark.

It was not possible to shoot any gannets in Natal and no stomach contents were examined. No small fish other than pilchards were found in the area, however, and gannets were seen to be fishing for and feeding close to the shore on many occasions when hauls consisting entirely of pilchards were made in *trek* nets.

(*b*) *Maasbanker*.—Maasbankers were found to make up approximately one sixth of the total food of the gannet on a basis of frequency alone, and slightly more on a basis of the estimated total weight of the organism at the time of eating (see Fig. 6).

Maasbankers found in gannet stomachs were not often mixed with other species and consisted generally of small fish seldom exceeding 20 cm in total length. On rare occasions gannets were recorded having pilchards together with maasbankers in their stomachs.

Maasbankers were eaten during winter, spring and summer, but mainly in spring and summer. They were recorded in stomach contents during each month from August to December and again in February.

According to commercial catches, maasbankers were available in the St. Helena Bay area from March to September and January to February (see Fig. 3), while observations from the small vessels of the Division of Fisheries showed them to be present during the four months of the closed season (September to December) as well. In spite of their presence all the year round, however,

it appeared that gannets showed a preference for pilchards whenever possible.

Although it is not suggested that a deliberate choice of prey from the point of view of quality of fish is made by the gannet, it is probable that there is some factor which makes pilchards preferable to maasbankers. This factor may well be related

It appears therefore that the gannet feeds on maasbankers to a certain extent, depending on their availability in relation to other fish, ease of capture and suitable size. The maasbanker has lately increased in importance as a commercial species and has now reached the same status as the pilchard in the fisheries of the Union.

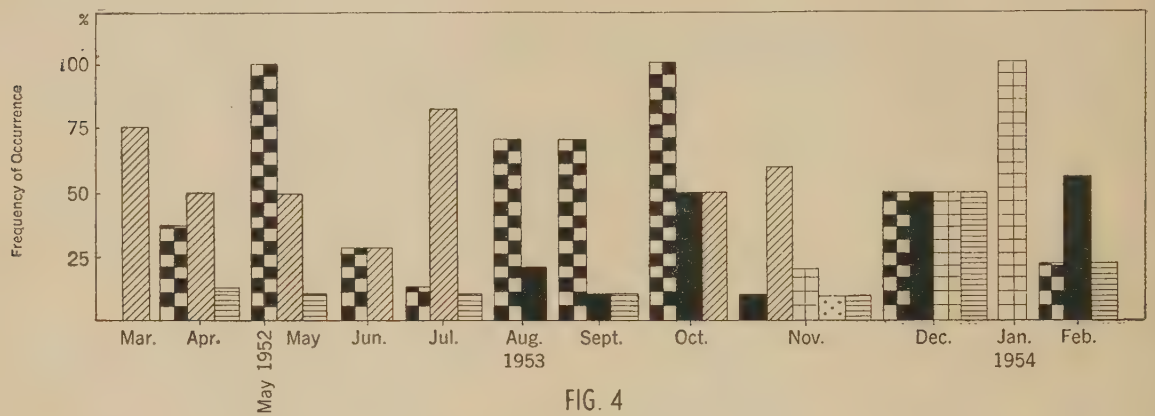


FIG. 4

THE FOOD OF THE CAPE GANNET (FREQUENCY)

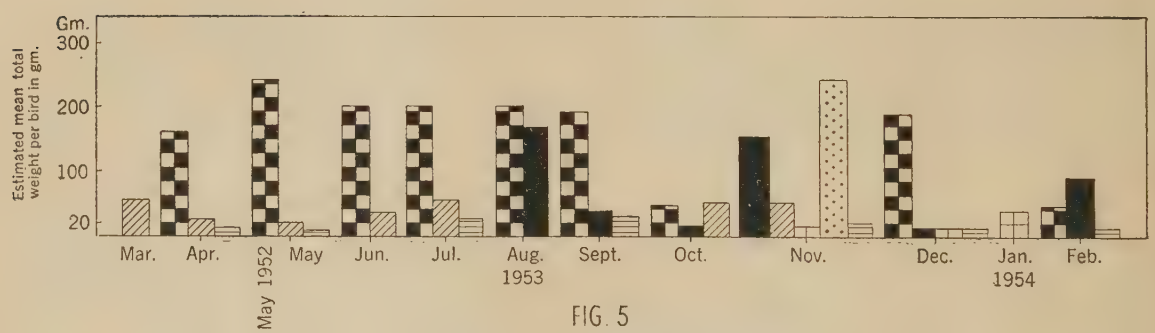


FIG. 5

THE FOOD OF THE CAPE GANNET (WEIGHT)

Mackerel
Harder
Fish remains
Pilchard
Maasbanker
Anchovy

Trigsurvey, 1954

Government Printer, 1954.

to availability or it may be that pilchards are easier to catch than maasbankers. From personal observation it seems more than likely that pilchard shoals are more easily located during the day than maasbankers, due to the fact that the former move closer to the surface. It is also significant that the majority of gannets disappear from the area when pilchards are absent.

(*c*) *Anchovy*.—Anchovies were found to make up over one third of the total food of the gannet on a frequency basis, but when the estimated weight of the organism at the time of eating was taken into consideration, this fraction became reduced to one ninth (see Fig. 6). This is a direct reflection of the smaller size of the anchovies eaten, relative to other species such as pilchards and maasbankers.

Anchovies obtained from gannet stomachs were not usually mixed with other speices, but on occasion records were made of stomachs containing anchovies together with pilchards. Anchovies eaten by gannets were generally young fish of approximate total length 10 cm. The largest anchovies caught in nets in the St. Helena Bay area were, however, fish of total length 20 cm.

Anchovies were eaten by gannets during autumn, winter and spring. They were recorded in stomach contents in the months March to July inclusive, and October and November. No anchovies were found to have been eaten during the summer months.

Up to the present, no commercial use of anchovies has been made. This species, which occurs in the area where commercial fishing for pilchards and maasbankers takes place, is of smaller size and more slender build than the latter. In order to prevent the capture of juvenile pilchards and maasbankers, regulations exist which do not permit any reduction in mesh-size of the net used in the pilchard and maasbanker fishery. It is not possible to use netting of a size suitable for the catching of anchovies without there being a likelihood of catching young pilchards and maasbankers. It is hoped that a solution will be found in the careful control of the fishing season for anchovies using small mesh nets at a time when juvenile pilchards are not present in the area.

There is evidence that the gannet regularly eats anchovies when these are present in the area. Shoals have been seen to move at or near the surface and are therefore readily available to fishing birds. They are also inclined to be closely packed together and for this reason find difficulty in dispersing, and therefore become easy prey to such an efficient fisherman as the gannet.

(*d*) *Mackerel.*—Mackerel were found to make up one eighteenth of the food of the gannet on a frequency basis, and one sixth when considered in relation to the estimated weight at the time of eating.

Mackerel were usually found to have been eaten alone but were sometimes mixed with anchovies. They were usually small or young fish of approximate mean total length 10 cm.

They were recorded in stomach contents in late spring and summer only, i.e. during the months November, December and January. During this period large numbers of juvenile mackerel were present in the area.

The mackerel has recently become a fish of considerable commercial importance, particularly in relation to canning and is caught mainly during the summer months. During the remainder of the year, however, mackerel are not available in the St. Helena Bay area. The mackerel ,being a pelagic species, may vary its movements considerably and may be entirely absent from the area one year and present for many months during the following year.

The gannet fed on mackerel when they were available in large numbers during a period when pilchards were not available.

(*e*) *Harder.*—Harders were found to make up one hundred and twentieth of the total food of the gannet on a basis of frequency, and one twelfth on a basis of the estimated total weight of the organism at the time of eating.

Although harders were recorded in stomach contents on only one occasion during the year, it is felt that they may form a reserve food supply for gannets at any time when there is a scarcity of other fish. It is of interest to note that Liversidge (private communication) reports that large numbers of harders were found amongst regurgitated stomach contents of gannet on Malagas Island. These were large and typical of the extensive shoals of adult harders which are present in the St. Helena Bay area in inshore waters during most of the year.

The harder is of minor importance in this area where it is caught by means of a *trek* (seine) net and used in either fresh or dried salted form (*bokkems*) for local consumption.

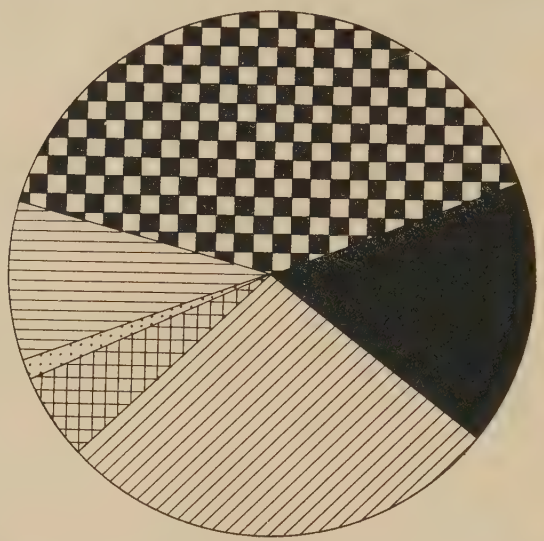
(*f*) *Fish remains.*—Fish remains were found in stomachs on many occasions, and it was nearly always possible to trace the species from which they had come. This was done by identifying skull bones, otoliths, vertebrae and other hard parts which were resistant to digestive action. On only seven occasions were semi-digested fish remains not classified.

(iv) Temperature.

All feeding during the year was found to have taken place in water with a temperature range of 11·5–16·5°C., the mean being 13·9°C. All temperatures were taken at the surface.

FIG.6.

FOOD DIAGRAM FOR CAPE GANNET.



A.

BY FREQUENCY OF OCCURRENCE.

Pilchard.

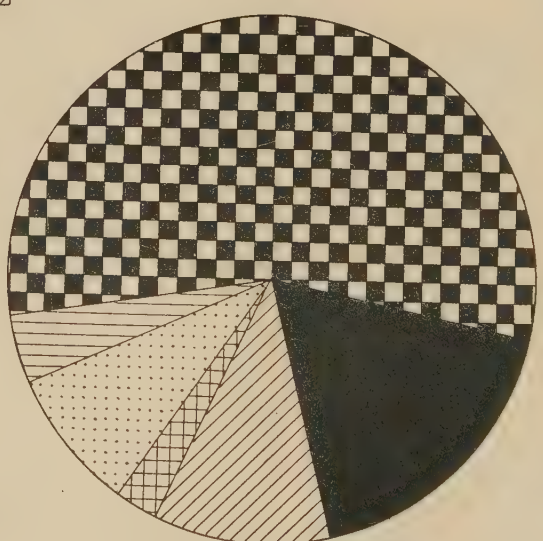
Maasbanker.

Anchovy.

Mackerel.

Harder.

Fish remains..



B.

BY WEIGHT

Trigsurvey, 1954.

Government Printer, 1954.

(v) Discussion.

It has been shown that the gannet population of the West coast feeds on five species of pelagic shoal-fish, two of which are of the greatest commercial importance, viz. the pilchard and the maasbanker. The remaining three are of commercial significance, either actual or potential. Active feeding took place during the greater part of the year in the area of commercial fishing. The weight of fish comprising a full "meal" for a gannet is estimated to be between 2½–3 lb, based on the weight of 1200 gm (2¾ lb.) recorded for a full stomach containing six large pilchards.

In order to gain some idea of the amount of fish consumed by the gannet population in a year it is necessary to know the daily consumption per bird and the total number of birds comprising the population. Unfortunately this information is not available at present but some indication may be given by consideration of the following:—

There are at least 10 hours of daylight during which gannets can fish in all seasons of the year. Although it has been shown that a full "meal" for an adult gannet is nearly 3 lb of fish, let 1½ lb be taken as being an average gannet meal. An allowance of 1½ hours for searching for prey, 1 hour for fishing and 2½ hours for sufficient digestion to have taken place to leave the stomach empty and so enable the bird to swallow another meal, gives a total of 5 hours for the complete operation. In 10 hours of daylight, therefore, two complete feeding operations involving two meals (i.e. 3 lb fish) will have been carried out.

The estimate of the time occupied by the gannet in searching for prey and fishing is based on personal observations made on many occasions over a long period. The time of 2½ hours for digestion is based on experiments carried out on gannets in captivity in which 2 hours were found sufficient time for evacuation of a stomach which had been three quarters filled.

If a gannet feeds successfully for say two thirds of the year, the other third being taken as non-feeding time due to bad weather, non-availability of fish, other activities of the bird such as breeding or any other eventualities, then 3 lb of fish will have been eaten every day for 244 days by each bird, making a total of 732 lb of fish per bird per year.

Broekhuysen (1951) estimated the gannet population of Malagas Island to be approximately 131,000 birds. It is considered that the majority of these birds feed in the St. Helena Bay area. A very conservative estimate of the whole population of gannets feeding in the latter area, including those from Penguin Islet at Lambert's Bay, is therefore given as 200,000 birds, although 250,000 is possibly nearer the correct figure.

Assuming the population to consist of 200,000 birds feeding at the rate of 732 lb of fish per bird per year, a total of 73,200 tons of fish will be eaten by the gannet population of the St. Helena Bay area per year.

It is admitted that the figure of 73,200 tons of fish per year is based partly on conjectural data.

The utmost caution has, however, been exercised and estimates have been made on a very conservative basis (e.g. half the maximum daily intake of food, only 10 hours feeding time for ⅔ of a year, etc.). This, together with a considerable amount of observation and experience, together with actual recordings of much data, numerical and other, may therefore give some indication of what is actually happening.

If the gannets eat 73,200 tons of fish per year, approximately 36,600 tons would consist of pilchards and 12,200 tons of maasbankers, representing approximately one quarter and one seventh respectively of the total commercial catches for the year 1953.

It is hoped that it will be possible to arrive at a more accurate estimation of the amount of fish consumed by the gannets of the West coast when further experiments on rates of digestion have been completed, and when full bird-census figures are available.

8. THE CAPE CORMORANT.

(i) General.

The Cape cormorant or *trekduiker* is a familiar bird of the South African coastline; it has been recorded from Angola right round the coast to Durban. Like the gannet the Cape cormorant is present in greatest concentrations in the St. Helena Bay area and off the South West African coast particularly Walvis Bay. The name *trekduiker* is well deserved, however, and this species is not only constantly on the move on daily foraging expeditions but appears to desert both breeding places (rookeries) and roosting places (usually rocks surrounded by sea) and disappears entirely from certain areas at times. Unfortunately, little or no work has been done on the migration of the Cape cormorant and no explanation has so far been given for these extensive movements.

Mass movements of cormorants have even taken place during the breeding season, thus leaving eggs and young birds deserted. While a great deal of the generally restless behaviour of the cormorant can probably be attributed to its never ceasing search for food, there appear to be other factors which cause it to move about. Desertion of rookeries during the breeding season could possibly be caused by interference or disturbance, lack of food supply or some other unfavourable circumstance.

(ii) Method of Feeding.

The feeding operations of the Cape cormorant appear to be less methodical than those of the gannet. Long, much extended flights of cormorants in "V" or line-ahead formation fly apparently aimlessly in different directions across the sea. Suddenly, however, the leading bird wheels sharply round and brings the flight round in its tracks, whereupon the whole formation

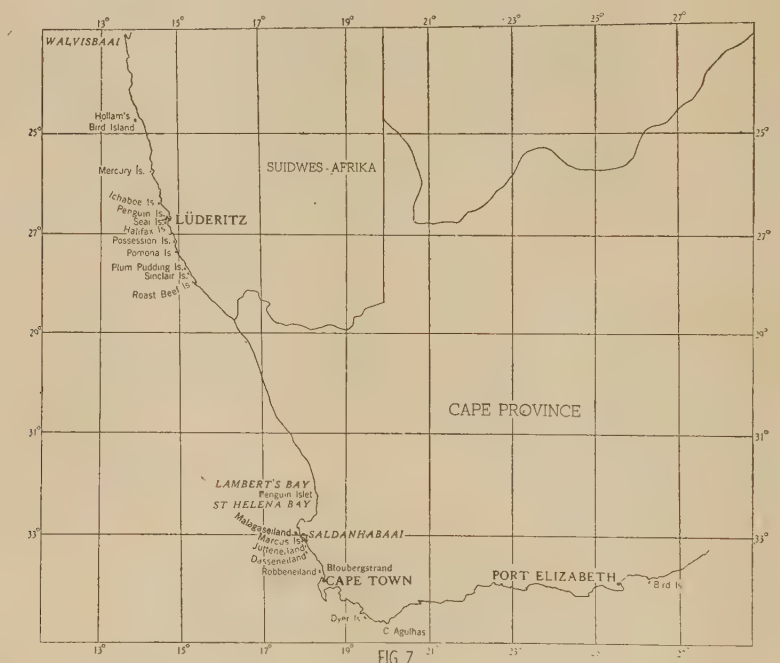


FIG. 7
BIRD ISLANDS
SCALE 1 4.000 000

Trigsurvey, 1954 — Government Printer, 1954.

Breeding of the Cape cormorant takes place in the spring and summer during the period September to February, with greatest activity during October and November. Nests are made on rocky islands round the coast such as Dyer's, Dassen, Penguin Islet (Lambert's Bay), Vondeling, Jutten, Marcus, Penguin and Seal Island (Luderitz Bay).

The Cape cormorant is a littoral species which avoids flying overland as far as possible and remains well within 30 miles of the shore, although individuals and small groups have been seen farther offshore. The average weight of the Cape cormorant is approximately 2 lb.

breaks up and individual birds flutter down to the sea and begin diving for fish.

During the periods when shoal-fish were plentiful in the St. Helena Bay area, a regular movement of cormorant flights took place every morning from roosting places to the areas where fish were present. The birds remained with the fish shoals throughout the day (although a certain amount of coming and going of birds took place) and were seen returning to roosting places from late afternoon till dusk. The morning migration was of short duration and consisted of a positive large scale movement of closely spaced flights in a single direction, while

the homeward movement consisted of odd flights flying slowly over many hours.

Fig. 8.—The Cape Cormorant (*Phalacrocorax capensis*).

When fish were not plentiful, however, the migrations of cormorants became much more haphazard. Flights were seen moving in different directions at all times of the day, probably searching for fish. The homeward movement started very early and most birds were at their roosting places long before dusk. In the morning there was no concerted migration in one particular direction and flights appeared to start off in many directions.

The diurnal migrations of cormorants amounted to an outward journey direct to a food supply or alternatively a search flight to locate a food supply, feeding operations, and then a return to roosting place. Once the prey, in the form of shoal-fish moving close to the surface, had been located, the cormorants arranged themselves on the edge of the shoal and proceeded to dive and catch fish. Each bird disappeared under water for a short time and reappeared either swallowing or about to swallow its prey. These dives were repeated at frequent intervals until the bird had apparently had sufficient, whereupon it swam away a short distance and rested on the water. A single cormorant was found to have as many as 20 pilchards of mean total length 8 cm in its stomach.

Although the cormorant is not anywhere near as spectacular a fisherman as the gannet, it appears that its methods are in every way as efficient. Cormorants were nearly always seen to be fishing in company with gannets and although both species were extremely active, the cormorants had the advantage that they did not have to take off and fly round in order to make another catch, but remained in the water and simply dived under on each occasion.

(iii) The Food of the Cormorant.

Although cormorants were not obtained during every month of the year, due mainly to their own unaccountable wanderings, sufficient numbers were obtained to give a very good indication of the variation of feeding during the seasons, and the results obtained are felt to be of considerable importance.

It is of interest to note that all stomachs of cormorants examined contained Nematode parasites of the genus *Contracaecum*. There were seldom very large numbers present and they appeared to do no harm to the bird.

The food of the cormorant was found to consist of the following:—

(*a*) Pilchard, *Sardinops ocellata* (Pappe).

(*b*) Maasbanker, *Trachurus trachurus* Linn.

(*c*) Anchovy, *Engraulis japonicus* (Houttuyn).

(*d*) *Paralepis* sp.

(*e*) Fish remains, unrecognisable.

(*f*) Rock Lobster, *Jasus lalandii* Milne Edwards.

(*a*) *Pilchard.*—This species was found to make up about one third of the total food of the cormorant on a frequency basis and nearly two thirds when the mean weight per pilchard eaten was considered (see Fig. 11).

Pilchards found in the stomach contents of cormorants were generally not mixed with other species of fish. They varied in size from large adults to small juvenile fish, but at the time the majority of cormorants were obtained, only the smaller sizes of pilchards were available in the area. It is possible that the cormorant may prefer larger fish thus making up a meal with less fishing effort than for small ones. Pilchards were eaten during spring, summer and autumn and were recorded in stomachs during the months November, December, February and March. Birds

112090—2.

obtained during June and July had no pilchards in their stomachs. Adult pilchards were found to have been eaten in March only; all other pilchards eaten by cormorants were juveniles.

Maasbankers were not found mixed with other species in stomach contents, and those eaten were small or juvenile fish with a mean total length of 8·5 cm.

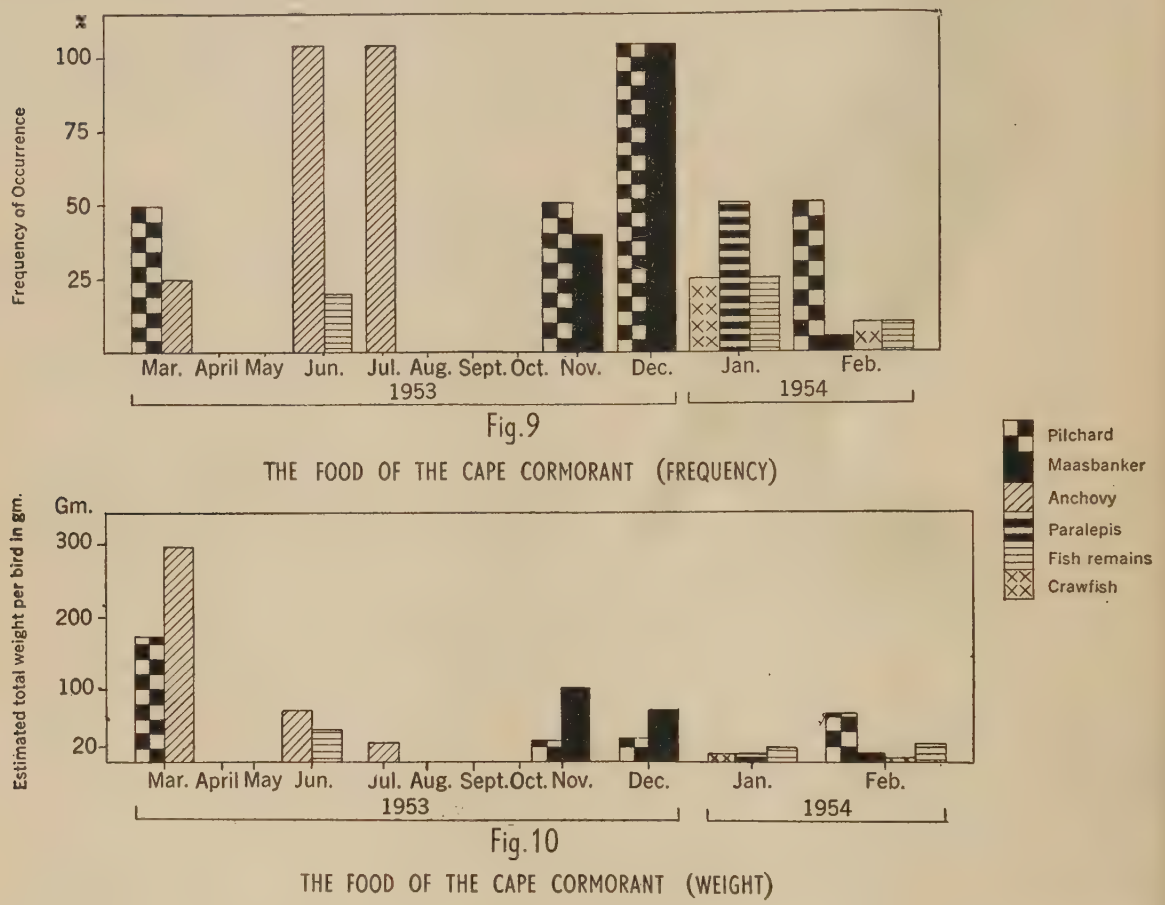


Fig.9

THE FOOD OF THE CAPE CORMORANT (FREQUENCY)

Fig.10

THE FOOD OF THE CAPE CORMORANT (WEIGHT)

Trigsurvey, 1954. Government Printer, 1954.

Although the sampling of cormorant stomachs was far less regular than that of the gannets, due mainly to the extensive and frequent migrations of the cormorants, it seems evident that the pilchard is a very important food organism of the cormorant, and the presence of pilchard shoals in the St. Helena Bay—Saldanha Bay area causes the congregation of large numbers of cormorants which actively feed on them.

(*b*) *Maasbanker*.—Maasbankers were found to make up approximately one fifth of the total food of the cormorant on a frequency basis and one tenth when the weight of individual fish eaten was considered (see Fig. 11).

They were recorded in stomach contents during spring and summer in the months of November, December and January only. No maasbankers were recorded during the months of March, June and July, although they were present in the area.

The maasbanker is a food organism of some importance to the cormorant, but adult maasbankers are probably not suitable as food due to their large size and high speed of swimming. Small maasbankers on the other hand are likely to be of considerable importance in the feeding of the cormorant.

(*c*) *Anchovy*.—This species was found to make up over one third of the total food of the cormoran

on a basis of frequency and less than one quarter when the relative weight of the organism at the time of eating was considered (see Fig. 11).

Anchovies were generally found to be unmixed with other species of fish in stomach contents. Small and medium-sized fish were eaten of mean total length 8·6 cm.

They were recorded in stomach contents during autumn and winter in the months of March, June and July. Although present in the area in November, no anchovies were found to have been eaten by cormorants.

Although the anchovies eaten were rather small in size, it seems likely that they are much sought after by cormorants and may be an item of considerable importance in their general diet.

(*d*) *Paralepis* sp.—Fourteen of these fish were recorded from two stomachs of cormorants shot in Table Bay in the month of January. Their mean total length was 12 cm and they were in a well-advanced state of digestion.

It is not suggested that this species is of significance in the diet of the cormorant.

It is of interest to note that the only other fish of the genus *Paralepis* recorded in this area were caught by a trawler on the trawling ground. Although the specimens obtained from the cormorant stomachs were in a very poor state, it is hoped that specific identification will be possible.

(*e*) *Fish remains.*—These were found in stomach contents on three occasions and did not include any part which could be used for identification.

(*f*) *Rock Lobster.*—Juvenile rock lobsters were found during the months of January and February in the stomachs of cormorants shot in both Table Bay and St. Helena Bay. They were small *post-puerulus* stages of mean total length 3 cm.

While the presence of rock lobsters in the stomachs of three birds only may seem unimportant, it is of considerable significance that these birds were shot as far apart as St. Helena Bay and Saldanha Bay and in different months. This may indicate that the rock lobster is not a casual item of food eaten on rare occasions, but an organism of some importance in the feeding of the cormorant. Only further investigation will show the degree of importance of young rock lobster in the diet of the cormorant.

(iv) Temperature.

Feeding was found to have taken place during the year in water with a temperature range of 13·1–16·2°C, at a mean temperature of 14·0°C. All temperatures were taken at the surface.

(v) Discussion.

It has been shown that the Cape cormorants of the West coast feed on four species of pelagic fish and on the young stages of the Cape rock lobster. Two of the fish species, viz. the pilchard and the maasbanker are of very great commercial importance, the anchovy is of considerable potential importance and the rock lobster of great importance. Active feeding took place all the year round, but was not continuous in that the entire cormorant population of the area was extremely fluid and considerable migratory movement took place at various times.

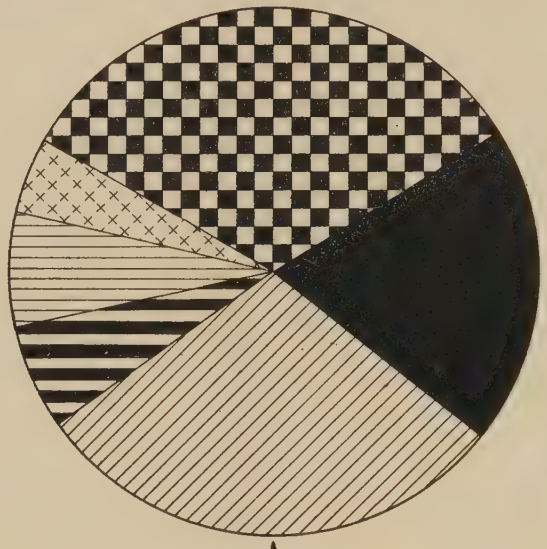
The weight of fish comprising a full " meal " for a cormorant is estimated to be about 1 lb, based on the examination of stomach contents in relation to capacity, and also on the experimental measurement of the cubic capacity of the stomach and oesophagus.

As there was no information available on the numbers of cormorants present in the area, a regular count of birds flying past Shell Bay Point near Stompneus was made over many months by the shore biologist stationed at the Stompneus field station. These counts were made from sunrise until the birds stopped flying past and were done with fair accuracy with the aid of a stopwatch. A detailed account of these counts will be published at a later date, but as a result of their having been made, it may be stated that as many as 23,000 cormorants fly from rookeries situated south of Shell Bay Point to feed in St. Helena Bay. Comparatively few birds appear to roost between Stompneus and Lambert's Bay and only small numbers were seen on Doctor Reef, Kelp Rocks, and off Cape Deseada. It is estimated that about 7,000 birds fly south to feed in St. Helena Bay, giving a total number of feeding cormorants in the area of 30,000 birds.

Let us take 10 hours as being the period of daylight in which cormorants could fish all the year round, and take ½ lb of fish as being an average meal, based on the estimation of 1 lb for a full " meal " as reflected by the examination of stomach contents. An allowance of 1½ hours for searching for prey, 1 hour for fishing and 2½ hours for sufficient digestion for evacuation of the stomach to enable the bird to swallow another meal, gives

FIG. 11.

FOOD DIAGRAM FOR CAPE CORMORANT.



A.

BY FREQUENCY OF OCCURRENCE.

Pilchard.

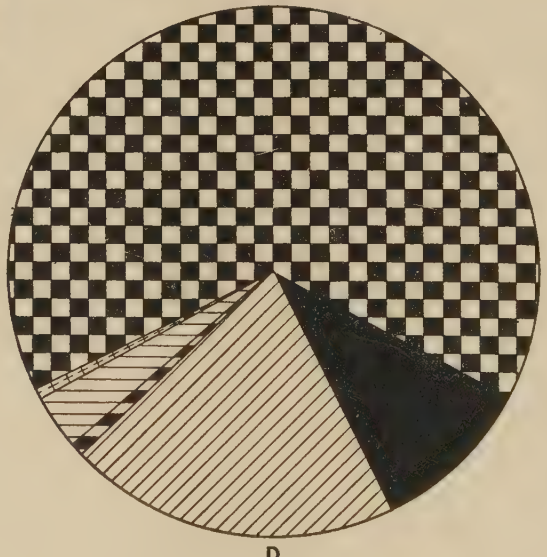
Maasbanker.

Anchovy.

Paralepis.

Fish remains.

Rock Lobster (Crawfish).



B.

BY WEIGHT

Trigsurvey, 1954.

Government Printer, 1954.

a total of five hours for the complete operation. In 10 hours, therefore, two complete feeding operations involving two meals which make a total of 1 lb of fish will be carried out.

The times allowed for searching for prey and fishing are the same as those allowed for the gannet and are based on personal observation of cormorants and gannets feeding together in St. Helena Bay. The time allowed for digestion to the stage where the stomach becomes empty is based on experiments carried out on cormorants in the laboratory. These tests showed that less than 2 hours was sufficient for the evacuation of a full stomach.

Let us assume that a cormorant feeds successfully for only two-thirds of the year, the other third being taken as non-feeding time due to bad weather, non-availability of fish, other activities of the bird such as breeding, and any other eventualities. Then 1 lb of fish will have been eaten every day for 244 days, making a total of 244 lb of fish per bird per year.

Assuming the population of feeding cormorants in St. Helena Bay to be 30,000 birds, feeding at the rate of 244 lb of fish per bird per year, a total of 3,660 tons of fish will be eaten by the cormorants in the area. Of this amount approximately 1,800 tons would be pilchards and 550 tons maasbankers representing $\frac{1}{80}$ and $\frac{1}{170}$ respectively of the total commercial catches of these two species.

Again it must be stressed that these figures are largely based upon inadequate data and further, all estimations have been made on a very conservative basis. It is therefore probable that the amount of fish of commercial value consumed by the cormorants of the St. Helena Bay area is considerably higher. It is hoped that it will be possible to give a more accurate idea of the consumption of fish by cormorants when more detailed data on feeding, census, etc. are available.

When considering the feeding of cormorants in general it may be of interest to know some of the results of the investigations made on the feeding habits of the Black cormorant (*Phalacrocorax carbo*) of New Zealand (Williams 1945). This is a much larger species than the Cape Cormorant and is closely related to the White-breasted Cormorant (*Phalacrocorax carbo lucidus*) which occurs on the West coast.

Williams carried out an experiment with a captive black cormorant in order to establish how much it would eat in one day. This particular bird was accustomed to feeding itself and did not require force-feeding. Between 5 a.m. and 8.10 p.m. it ate a total of 81 mullet of average length 6 in. making up a total weight of 10 lb 2 oz. The largest number eaten at a time was 18 which made up the first meal (weight approximately 1 lb 10 oz).

A further experiment was carried out over a period of two years in which it was established that the minimum amount of fish required per day to keep the captive cormorant alive was approximately 10 oz. Williams found that unless his bird received this quantity it rapidly lost weight and became weak.

From examinations of stomach contents and observations at the rookeries, Williams concluded that black cormorants catch much more fish during the breeding season and he calculated that each bird's daily catch was over 15 lb of fish. His estimate of the out-of-breeding season daily average was 8 lb per bird.

While these experiments concern birds of a different species from the Cape cormorant and which occur in another part of the world, they were carried out over a long period and in a unique manner and are therefore of much value in any consideration of the feeding of our own species.

9. THE CAPE PENGUIN.

(i) General.

The Cape or Jackass penguin is a widely distributed South African species which is found in varying numbers from Cape Cross to Durban. Being flightless birds and spending the greater part of their lives in the water, the presence of penguins is never as striking as that of gannets or cormorants. They are, however, present in large numbers along the coast from Hollam's Bird Island to Port Elizabeth.

Breeding of the Cape penguin takes place in spring, early summer and autumn, November and March being the principal months. The main breeding centres of the penguin are Dyers, Dassen, Jutten, Marcus, Plum Pudding, Pomona, Possession and Halifax Islands. Nesting is usually carried out in burrows underground.

Penguins generally remain close to the shore in coastal waters and are usually seen in pairs or small groups. They are seldom seen beyond 25

miles from the coast, but records show that they may venture farther out to sea.

Fig. 12.—The Cape or Jackass Penguin (*Spheniscus demersus*).

(ii) Method of Feeding.

The feeding of the Cape penguin is different from that of the cormorant and the gannet in that all operations are conducted in the sea. This might appear a serious disadvantage to the penguin which has to search for its food and cover the same distance as the other birds without the ability to fly. The entire absence of aerial search in the location of prey in the feeding methods of the penguin is apparently well compensated for by the great facility with which it swims. There is no doubt that penguins cover great distances in searching for fish, and, judging by their progress through the water alongside R.S. *Africana II*, they are capable of swimming at fairly high speeds. It is not known whether such speeds could be maintained for any length of time, but if their normal cruising speed were 4–5 knots, a considerable distance could be covered in a day.

Penguins were seen singly, in pairs, or in groups of fifty or more feeding at various times on shoal-fish. They floated at the surface for a while and suddenly dived and reappeared some distance away having apparently swallowed their prey. Penguins were not usually seen in the act of swallowing fish when on the surface as the prey was usually caught and swallowed under the surface.

In general, the penguin was far less obtrusive than the cormorant and gannet in the St. Helena Bay and Saldanha Bay areas, yet when shoal-fish were being attacked by birds, numbers of penguins were invariably present. The fact that they could not fly did not in any way detract from their deadly efficiency as fishermen, and because they dive rapidly without even disturbing the surface of the water penguins are probably as efficient at catching fish as cormorants or gannets.

Little is known of the duration of a normal fishing tour of the penguin. It may consist of a daily journey from a land base, rookery or roosting place to the fishing grounds and a return to the same place in the evening, or an expedition lasting for a longer period and running into days or even weeks. It seems probable that non-breeding penguins would be more likely to go on protracted feeding expeditions, while breeding birds would be restricted to short feeding trips in the immediate vicinity of the islands.

Although penguins are never very much in evidence in the area, their prowess as fishermen cannot be denied and it is felt that they are responsible for the consumption of considerable quantities of fish.

(iii) The Food of the Penguin.

Due to the fact that penguins were shot only in the summer months towards the end of the year under review, the list of food organisms below does not indicate seasonal changes in feeding or other variations during the year. The results obtained, however, show a wide variety of species of fish eaten including commercial species, and appear to be of considerable significance. The food of the penguin was found to consist of the following:—

(*a*) Pilchard, *Sardinops ocellata* (Pappe).

(*b*) Maasbanker, *Trachurus trachurus* Linn.

(*c*) Anchovy, *Engraulis japonicus* (Houttuyn).

(*d*) Mackerel, *Scomber japonicus* Houttuyn.

(*e*) Harder, *Liza ramada* (Risso).

(*f*) Fish remains, unrecognisable.

(*g*) Rock Lobster, *Jasus lalandii* Milne Edwards.

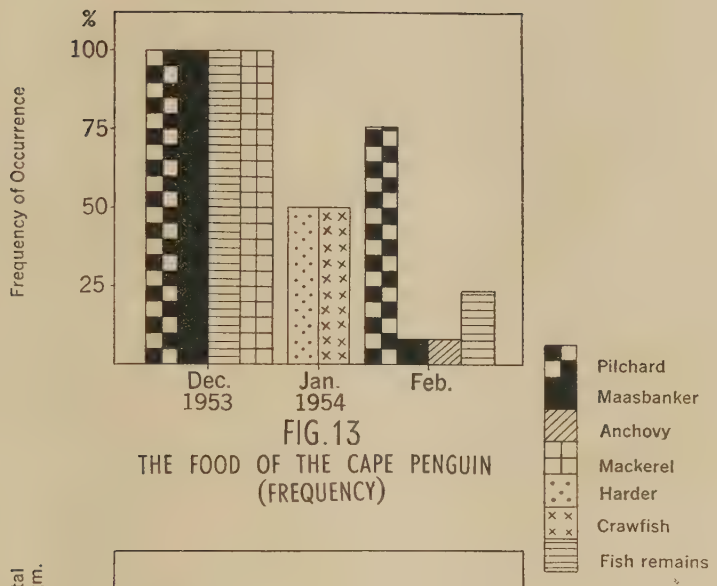


FIG.13
THE FOOD OF THE CAPE PENGUIN
(FREQUENCY)

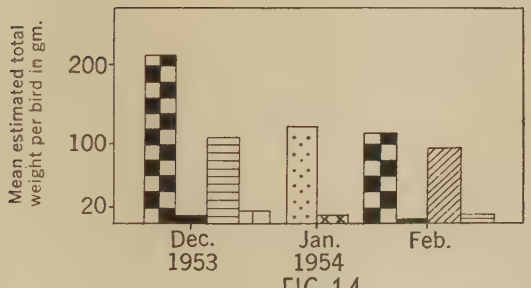


FIG.14
THE FOOD OF THE CAPE PENGUIN.
(WEIGHT)

Trigsurvey, 1954. Government Printer, 1954.

(*a*) *Pilchard.*—Pilchards were found to make up approximately one third of the total food of the penguin on a frequency basis and just over one third when the weight of the organism at the time of eating was considered (see Fig. 15). Pilchards found in penguin stomachs were sometimes mixed with other fish such as maasbankers. All the pilchards eaten during the period investigated were young or juvenile fish, probably due to the fact that adult pilchards were not available in the area during the summer months. It is likely, however, that the penguin eats larger pilchards at other times of the year. Pilchards were found in penguin stomachs during two of the three months investigated, i.e. December and February, and it is likely that they are an important item in the general diet of the penguin.

(*b*) *Maasbanker.*—This species was found to make up over one sixth of the total food of the penguin on a frequency basis, but only one thirtieth when considered on a basis of the weight of the fish at the time of eating (see Fig. 15).

Maasbankers were found to have been eaten together with young pilchards, and were young fish of mean total length 7·5 cm. They were recorded during two of the three months investigated, viz. December and February, and may be a species of some importance in the feeding of the penguin.

(*c*) *Anchovy.*—Anchovies were found to make up only one seventieth of the food of the penguin on a frequency basis but as much as one sixth when the weights of the fish at the time of eating were considered (see Fig. 15).

Anchovies were found to have been eaten together with young pilchards and were mainly medium-sized fish of total length 9 cm. They were recorded during February only of the period investigated, but as many as fourteen fish were found in one stomach. The anchovy may be of some importance as a food organism to the penguin.

(*d*) *Mackerel.*—Mackerel formed less than one sixth of the food of the penguin on a frequency basis and one fortieth when the weight of fish eaten was considered.

Mackerel were eaten with other fish such as pilchards and maasbankers, were of mean total length 12 cm and were recorded in December only. Young mackerel are probably eaten whenever available in sufficient numbers.

(*e*) *Harder.*—This species formed about one twelfth of the food of the penguin on a frequency basis and approximately one fifth when the weight of the organism at the time of eating was considered (see Fig. 15).

Harders were not found mixed with other organisms in stomach contents and consisted of small fish of mean total length 2·4 cm. They were recorded during January in the stomach of a penguin obtained in Table Bay, and it is possible that close to rookeries they are a good standby for penguins.

(*f*) *Fish remains.*—Fish remains which could not be identified were found in stomach contents on two occasions.

(*g*) *Rock Lobster.*—On one occasion seven juvenile rock lobsters of mean total length 2·6 cm were found in the stomach of a penguin during the month of January in Table Bay. These were *puerulus* stages and it is likely that they are regularly eaten by penguins when available.

(iv) Temperature.

All feeding records of penguins were made in water with a temperature range of 13·3–13·8°C, at a mean temperature of 13·5°C. All temperatures were taken at the surface.

(v) Discussion.

It has been shown that the penguins of the West coast feed on five species of pelagic shoal-fish, two of which, viz. the pilchard and the maasbanker, are of great commercial importance and the remainder of commercial significance. They also feed on young rock lobster.

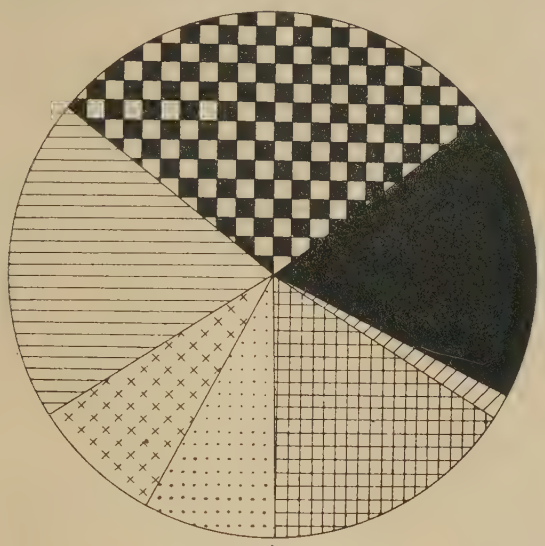
Unfortunately there is no information available on the numbers of penguins inhabiting the West coast, and it is not possible to make any estimation of the population. It is hoped that census figures will be available in the near future. Every effort will be made to obtain additional, more detailed data on the feeding of the penguin in order that results may be treated on the same basis as those obtained for the gannet and the cormorant.

10. GENERAL DISCUSSION.

During these times when the problem of food supply for the world's ever-increasing population is becoming a matter of considerable urgency, more and more exploitation of natural resources is taking place. In some cases over-exploitation has occurred, but in pelagic fisheries no clear-cut scientifically proved case of over-fishing has so

FIG. 15.

FOOD DIAGRAM FOR CAPE PENGUIN.



A.

BY FREQUENCY OF OCCURRENCE.

Pilchard.

Maasbanker.

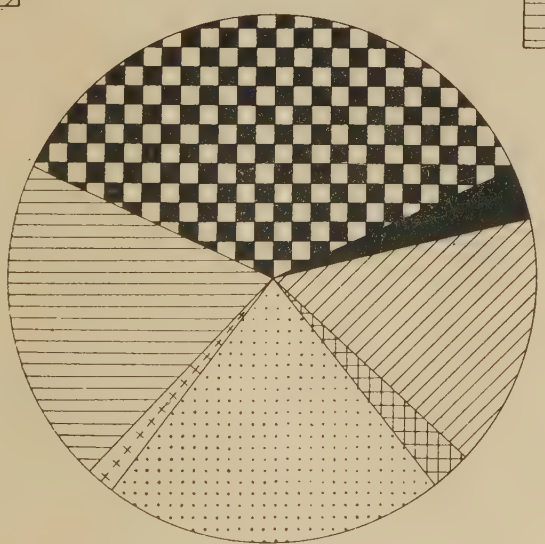
Anchovy.

Mackerel.

Harder.

Rock Lobster (Crawfish).

Fish remains.



B.

BY WEIGHT

Trigsurvey 1954

Government Printer, 1954.

far been established. There is always the possibility that a change in one of the multitude of natural or environmental factors in the life of the fish has been either the cause or a contributory factor in the decline of the fishery. There is no doubt, however, that the tendency for increased exploitation of all known and unknown fishing stocks is universal. With this growing tendency to fish stocks as closely as possible to their optima, there has been a recent development in the management of the fisheries of the world in which rigorous control of predators is advocated. The main object of such control is to make the amount of the prey which is normally consumed by the predators, available for the commercial fisheries and so increase the fishing potential.

Rigid control of predators in restricted waters such as lakes and rivers is often necessary for the carrying on of inland fisheries. In some cases this control is essential and the fisheries cannot continue without it. In sea fisheries predator control may have great possibilities, but up till now positive results of a conclusive nature have not been attained.

In any problem involving the control of predators, it must be remembered that predation is one of the most powerful forces in nature and is usually responsible for maintaining a balance of the prey population. For example, in restricted waters it has happened that the entire removal of predators has resulted in an over-abundance of prey, far too numerous for the available food supply. This has, in consequence, had disastrous effects on the prey population.

Ricker (1952) makes a broad distinction between warm-blooded and cold-blooded carnivorous predators. The former have a fairly constant food requirement, and hence are more likely to take a fixed fraction of the prey species present. Birds possess great mobility which enables them to move quickly to localities where food is temporarily abundant. At the same time they require a steady food intake to maintain body temperature and will quickly leave an area where food is so scarce that foraging does not provide their minimum needs. Predacious fishes, by contrast, require a much lower minimum ration per unit of body-weight, in order to continue with normal activities and have much greater flexibility in the amount of food they can consume., They are prepared to take whatever food they encounter as often as they encounter it.

Having given brief consideration to the possibilities of the control of predators, some mention must be made of the knowledge required about a predator–prey relationship before any attempt should be made at interference, such as control or elimination of predators. It is considered that the following should be known:—

(1) The general biology of the prey species in broad outline, at least, and in particular information on the season of reproduction, development, rate of growth, feeding and migration.

(2) The composition of the prey-population in relation to size, age and numbers.

(3) The general biology of the predator species in broad outline, and in particular information on the season of reproduction, development, rate of growth, feeding and migration.

(4) The composition of the predator-population in relation to size, age and numbers.

To be in possession of all the above information would be to have attained a rare standard of perfection, if it were possible. But, at least some knowledge of the different aspects of the biology of both predator and prey should be a basic essential of predator control.

In considering the predation of sea-birds on fish, probably the most important factors to be established are firstly, the species of fish which the birds eat and to what extent, and secondly, how many sea-birds are eating that amount of fish in any definable area.

There have been numerous attempts in the past to assess the numbers of sea-birds present on the South African coast and the quantities of fish which they consume.

For example, the Director of Fisheries (1934) estimated that there were about 20,000,000 *duikers* (cormorants) along the coast of the Union which consumed about 8,000,000 tons of fish per year.

Senator Pettersen (1954) was of the opinion that if there were 20,000,000 *duikers* in 1934 then there must be at least 35,000,000 *duikers* off the Union coast at the present time. He estimated that these consumed 15,000,000 tons of fish per annum.

It is not certain how the above estimates were made, but as far as is known, no general census figures or bird counts of sea-bird populations were available in 1934, or for that matter, are available

at present. Similarly, no published records on the amount of fish consumed by cormorants in South African waters are available. These figures are therefore considered to be unacceptable in the absence of any scientific data.

Sen. Pettersen's opinion that the cormorant population had increased by 15,000,000 and in consequence its consumption of fish by 7,000,000 tons per year, is hardly tenable as it is not based on any scientific records. The opinion held by members of the Guano Islands Division is that the number of cormorants has considerably decreased during recent years. This opinion has been supported by actual recordings of large scale mortality of cormorants on some of the islands. Personal observation and regular counts in the vicinity of St. Helena Bay have not given any indication of an over-abundance of cormorants, and guano yield due to deposits by cormorants has not increased.

A further attempt to assess the fish mortality due to bird predation was made by Neale–May (1950). He wrote:—

> "It has been estimated that there are 10,000,000 birds on the West coast living entirely on sea-food. The average body weight of these birds could be taken conservatively at 2 lb, and as each bird is believed to eat its own weight of fish per day, it can be calculated that the birds alone remove from the sea 10,000 tons of fish per day, or about 3,500,000 tons per year."

It is not known what scientific findings were used as a basis for these figures. No general census of the sea-birds of the West coast has so far been made, and it has not been established that the birds eat their own weight of fish per day. It may be said therefore that any estimates of the fish consumption of the sea-birds of the South African coast, which have so far been made, are unreliable due to the fact that no basic data were available for such estimates.

On the basis of the scientific findings set down in this paper, the estimated consumption, on a conservative basis, by the gannets and cormorants of the St. Helena Bay area is 38,800 tons of pilchards and 12,550 tons of maasbankers per year. This amounts to a total of 51,350 tons of fish of commercial importance per year. There is no doubt that penguins are also responsible for the consumption of large quantities of pilchards and maasbankers, but in the absence of sufficient records of the feeding of penguins, no attempt to estimate their consumption has been made. As no census figures of the three species of birds mentioned above are available for other parts of the Union's coasts, no attempt to extend these estimates has been made.

It is of interest to consider the values of pilchard and maasbanker catches in relation to the quantities of these fish consumed by birds, and the relative values of bird products such as guano and eggs.

The total catch for the Union of South Africa for the year 1953 was 142,023 tons of pilchards and 87,271 tons of maasbankers. The landed value of these together was approximately £917,176, but the total value of these catches in terms of canned products, fish meal and oil was approximately £4,548,000. On the same basis the 51,350 tons of pilchards and maasbankers eaten by the gannets and cormorants would be worth £205,400 in terms of landed value and nearly £1,000,000 in terms of final fishery products. It will be remembered that the annual fish consumption of the penguin was ignored. With the inclusion of the fish eaten by the penguins of the St. Helena Bay area, it is not unreasonable to assume that the value of the commercial fish eaten by the three main guano-producing birds in this area per year is more than £1,250,000, expressed in terms of the value of the final fishery products.

The total guano yield for the year 1953 was 5,600 tons, and the total number of penguin eggs collected during the year approximated 148,000. The total final sale value of guano and penguin eggs together was approximately £65,000, according to the Superintendent of the Guano Islands Division. The cost to this Division of the production of the guano and eggs, including administration and maintenance of the Islands, collection of guano etc. was £74,600. The deficit for the year in respect of guano and egg collection was therefore £9,600. Guano is considered so valuable a fertiliser for the market gardener, however, that the Government is prepared to provide as much as possible and subsidises it to the extent of £1 a ton, the guano being sold at £11 a ton during 1953.

It may seem unreasonable, on the face of it, to protect sea-birds from which are obtained products which although valued at £65,000 actually cost the country £9,600. It may seem even more unreasonable when it is borne in mind that the potential value of fish consumed by the guano-producing birds of one section of the West coast is in the vicinity of £1,250,000.

Although the policy of "guano-farming" may seem unbusinesslike, it must be remembered that the loss on guano every year is compensated for by the profit in sealing operations carried out by

the Guano Islands Division. Since guano is a very valuable fertiliser, which is at present essential to the market gardener, every effort should be made to maintain the supply. But when suitable fertiliser can be supplied at a reduced price from other sources, it would be unwise to continue with the collection of guano unless it could be done on a profitable basis.

From the research done on the pilchard and maasbanker it seems likely that the populations fished in Union waters have so far been able to withstand the total amounts caught every year. It is not known, however, whether more than the permitted 250,000 tons can be removed or whether this amount already exceeds the optimum. Further, the possibility of natural depletion, due to unknown biological or environmental factors, is always present. Every effort is being made on the part of the Division of Fisheries to establish just how much fish of these two species may be caught per year, but it may take a long time.

It might be argued that if 250,000 tons of pilchards and maasbankers are caught commercially every year in the St. Helena Bay area alone, and the birds of that area consume 50,000 tons, the area can stand a total annual catch of about 300,000 tons. This being so, why not destroy all the birds, give up guano production and permit the erection of three new factories to catch and process the 50,000 tons normally consumed by the birds ?

The answer lies in the fact that a full knowledge of all the facts is not at present available. The country is making a good annual catch of pilchards and maasbankers which up till now have shown no sign of being depleted. The guano birds of the area are eating their share of the fish from the same area without any apparent adverse effect on commercial fishing. At the same time they are producing an organic fertiliser of high nitrogen content which is used for the production of essential food, viz. fresh vegetables. Further, the birds may well be exercising some kind of natural control over the fish stocks, which may be essential to the well-being of the fish. It seems therefore that any interference with the *status quo* would be most unwise until research into the general biology, bionomics and environment of both the predators and the prey has advanced sufficiently to warrant modification or adjustment of present policy in the light of new findings.

11. RECOMMENDATIONS.

(1) That no steps be taken at present to control sea-bird predators off the west coast of the Union of South Africa and the protection presently accorded to sea-birds should not be relaxed.

(2) That further research be carried out in relation to both predators and prey.

(3) That a census of gannets, cormorants and penguins, inhabiting the whole coast of the Union, be made without delay in order to establish the approximate composition of each population. This census should be made at least four times, each time in a different season of the year, before final figures are established.

(4) That the whole question of sea-birds and their relationship to commercial fisheries and guano production be reviewed from time to time whenever new facts become known.

(5) That research into sea-bird predation be extended to include the fisheries of South West Africa.

12. ACKNOWLEDGMENTS.

The writer is indebted to the following:—

Dr. J. M. Marchand, Director of Fisheries, Mr. C. G. du Plessis and Dr. A.J. Clowes for critically reading this paper; to Mr. Maasch, Superintendent of the Guano Islands Division for permission to shoot protected sea-birds, for giving information required for this paper and for many constructive suggestions which were of considerable benefit; to Messrs. K. van Rensburg, D. van Schoor and F. Kallis for much practical assistance; to Dr. G. J. Broekhuysen of the University of Cape Town for his photograph of the gannet in flight; to Dr. Broekhuysen and Mr. R. Liversidge of the University of Cape Town for access to unpublished data on ring returns, and to Mr. R. W. Rand of the Guano Islands Division for information on the birds.

13. REFERENCES.

BARNARD, K. H., 1925.—*Monograph of the Marine Fishes of South Africa.* Ann. S.A. Mus., XXI, 1 and 2, pp. 1–1065. Edinburgh.

BAYLIS, H. A., 1936.—*The Fauna of British India.* I, Nematoda, pp. 1–408. London.

BROEKHUYSEN, G. J., and RUDEBECK, G., 1951.—*Some Notes on the Cape Gannet, Morus capensis.* The Ostrich, XX, 3, pp. 1–7. Cape Town.

GURNEY, J. H., 1913.—*The Gannet.* pp. 1–567. London.

HARTLEY, P. H. T., 1948.—*The Assessment of the Food of Birds.* The Ibis, 90, 3.

MACK, G., 1941.—*Cormorants and the Gippsland Lakes Fishery.* Mem. Nat. Mus. Vict., 12, pp. 95–117. Melbourne.

MURPHY, R. C., 1936.—*Oceanic Birds of South America.* I and II, pp. 1–1245. New York.

NEALE-MAY, W. M., 1950.—*Survey of the South African Fishing Industry with Special Reference to Fish Meal and Oil.* S.A. Indust. Chem., 4, No. 12, pp. 226–230. Johannesburg.

RAND, R. W., 1950.—*The Government Guano Islands: Birds and Seals.* "Farming in South Africa", 7119, pp. 1–15. Pretoria.

RAND, R. W., 1952.—*The Birds of Hollamsbird Island, South West Africa.* The Ibis, 94, pp. 452–457.

RAND, R. W., 1952.—*Guano Enterprise in South West Africa.* The Ostrich, XXIII, 3, pp. 1–17.

RICKER, W. E., 1952.—*Numerical Relations between Abundance of Predators and Survival of Prey.* Canadian Fish Culturist, 13, Dept. of Fish., pp. 1–5. Ottawa.

ROBERTS, A., 1940.—*The Birds of South Africa.* Central News Agency, Johannesburg.

ROUNSEFELL, G. A., and EVERHART, W. H., 1953.—*Fishery Science.* pp. 47–48. New York.

SERVENTY, D. L., 1938.—*The Feeding Habits of Cormorants in South-Western Australia.* Emu, XXXVIII, pp. 293–316. Perth.

SMITH, J. L. B., 1949.—*The Sea Fishes of Southern Africa.* Central News Agency, pp. 1–550. Cape Town.

STEPHEN, G. A., 1933.—*The Food Consumed by Shags and Cormorants around the Shores of Cornwall (England).* Jour. Mar. Biol. Ass., XIX, 1, pp. 277–292. Plymouth.

VAN DOBBEN, W. H., 1952.—*The Food of the Cormorant in the Netherlands.* Ardea, Jaargang 40, Aflevering 1/2, pp. 1–34. Leiden.

WILLIAMS, H. G., 1945.—*The Shag Menace.* pp. 1–94. Dunedin (New Zealand).

———, 1934.—*The Fishing Industry.* Board of Trade and Industries, Rep. No. 180, pp. 1–90. Pretoria.

———, 1954.—*The Senate of the Union of South Africa.* Debates No. 11, pp. 2559–2591. Cape Town.

———, 1953.—*Cape Argus,* 26th July, Cape Town.

TABLE 1.—THE FOOD OF THE CAPE GANNET.

Month.	Locality.	Surface Temp. °C.	Food Organism in Stomach.	Number of Birds in which found	Highest Number of Organisms per Bird.	Total Number from All Birds.	Mean Total Length of Food Organisms. cm.	Total Weight of All Food Organisms. gm.	Mean Weight per Organism. gm.	Total Weight of All Organisms at Time of Eating. gm.	Mean Weight per Organism at Time of Eating. gm.	Number of Birds Shot.	Remarks.
1952.													
April.....	St. Helena Bay.	13·2	Anchovy.....	2	9	15	—	—	—	—	—	2	Too digested for measurement of total lengths.
May.....	St. Helena Bay.	13·0	Pilchard.....	5	6	10	21	—	—	1,200*	120*	5	Mean total length for the 6 pilchards in one stomach: 24 cm.
October...	St. Helena Bay.	15·0	Pilchard.....	2	3	5	23*	528	109	528	109	2	Pilchards freshly eaten.
November.	Table Bay.....	15·7	Anchovy.....	1	29	29	10	205	7	205	7	1	Anchovies freshly eaten.
1953.													
March....	St. Helena Bay.	16·8	Anchovy.....	3	58	72	5	166	2	166	2	4	Anchovies freshly eaten.
April.....	St. Helena Bay.	14·3	Pilchard.....	3	2	4	24	371	93	480*	120	—	Pilchards in different stages of digestion.
			Anchovy.....	4	5	18	9*	99	5·5	110*	5·6*	—	
			Fish remains.	3	—	—	—	39	—	—	—	—	Unrecognisable.
	Saldanha Bay..	—	Empty.....	1	—	—	—	—	—	—	—	8	Stomach empty.
May.....	St. Helena Bay.	14·1	Anchovy.....	5	4	15	10*	64	4	75	5	—	
			Fish remains.	1	—	—	—	1·6	—	—	—	—	
			Empty.....	4	—	—	—	—	—	—	—	10	
June.....	St. Helena Bay.	13·8	Anchovy.....	3	7*	14*	10*	87	6·2	98*	7	—	
	Blouberg.....	14·5	Pilchard.....	3	1	3	—	—	—	600*	—	11	
July.....	St. Helena Bay.	13·0	Anchovy.....	9	20	76	10*	275	3·6	520*	6·8*	—	
			Fish remains.	1	—	—	—	23	—	—	—	—	Unrecognisable.
	Blouberg.....	13·3	Pilchard.....	2	2	3	25	—	—	410*	137*	11	
August...	St. Helena Bay.	13·3	Pilchard.....	7	4	14	22*	1,290	92	1,400*	100*	—	
			Maasbanker..	2	2	3	—	300	100	330*	110*	10	
September.	St. Helena Bay.	13·3	Pilchard.....	7	4	15	22*	1,289	85	1,383	92	—	Pilchards in different stages of digestion.
			Maasbanker..	1	1	1	—	37	37	—	—	—	Well digested.
			Fish remains.	1	—	—	—	27	—	—	—	—	Unrecognisable.
			Empty.....	1	—	—	—	—	—	—	—	10	
October...	St. Helena Bay.	13·5	Pilchard.....	2	6	6	8·5	36·1	9	37*	9*	—	Two pilchards small and very much digested.
			Maasbanker..	1	1	1	—	—	—	—	—	—	Small fish very well digested.
			Anchovy.....	1	7	7	9·5	42	6	49*	7*	2	Freshly eaten.
November.	St. Helena Bay.	14·1	Maasbanker..	1	2	2	20·5*	146·3	73·2	150*	75*	—	Freshly eaten.
			Mackerel....	2	2	3	—	22·6	7·5	30*	10*	—	
			Anchovy.....	6	5	20	13·5	272·7	13·6	300*	15*	—	
			Harder.....	1	3	3	—	243·9	81·3	244*	81*	—	
			Fish remains.	1	—	—	—	20	—	—	—	—	Freshly eaten.
			Empty.....	1	—	—	—	—	—	—	—	—	Small fish, possibly anchovies.
December.	St. Helena Bay.	13·9	Pilchard.....	1	39	39	8·5	184·9	4·7	184·9*	4·7*	10	
			Maasbanker..	1	1	1	9·0	8·5	8·5	9*	9*	—	Freshly eaten.
			Mackerel....	1	1	1	10	9·7	9·7	—	—	—	
			Fish remains.	1	—	—	—	8·5	—	—	—	—	
1954.												2	Unrecognisable.
January...	Table Bay.....	12·6	Mackerel....	1	1	1	—	—	—	—	—	1	Small mackerel, well digested.
February..	St. Helena Bay.	13·9	Pilchard.....	2	3	6	12	88·3	14·7	88·3*	14·7*	—	Freshly eaten.
			Maasbanker..	5	4	9	19	400·8	44·5	450*	50*	—	Different stages of digestion.
			Fish remains.	2	—	—	—	23·3	—	—	—	9	
											TOTAL.....	98	

* Calculated from available data.

TABLE 2.

THE FOOD OF THE CAPE CORMORANT.

Month.	Locality.	Surface Temp. °C.	Food Organism in Stomach.	Number of Birds in which found	Highest Number of Organisms per Bird.	Total Number from All Birds.	Mean Total Length of Food Organisms. cm.	Total Weight of All Food Organisms. gm.	Mean Weight per Organism. gm.	Total Weight of All Organisms at Time of Eating. gm.	Mean Weight per Organism at Time of Eating. gm.	Number of Birds Shot.	Remarks.
1952.													
December.	Table Bay.....	13·2	Maasbanker..	2	9	13	9	169	18·8	180*	20*	2	Freshly eaten.
1953.													
March....	St. Helena Bay.	16·2	Pilchard.....	2	1	2	25	344	172	344*	172*	—	Freshly eaten
			Anchovy.....	1	32	32	4	56	1·7	288*	9*	—	Well digested.
			Empty.....	1	—	—	—	—	—	—	—	4	
June.....	St. Helena Bay.	13·9	Anchovy.....	5	15	44	10*	321·3	7·3	332*	7·5*	—	Mainly little digested.
			Fish remains.	1	—	—	—	43	—	—	—	5	Unrecognisable.
July.....	St. Helena Bay.	13·1	Anchovy.....	1	2	2	12*	20·5	10·3	22*	11	1	Lottle digested.
November.	St. Helena Bay.	14·6	Pilchard.....	5	20	45	8	126·7	2·8	158*	3·5*	—	Mainly well digested.
			Maasbanker..	4	17	53	8	346·6	6·5	398*	7·5*	—	Different degrees of digestion.
			Empty.....	1	—	—	—	—	—	—	—	10	
December.	St. Helena Bay.	13·6	Pilchard.....	1	10	10	6	30	3	30*	3*	—	Freshly eaten.
1954.			Maasbanker..	1	12	12	6	70	5	70*	5*	1	Freshly eaten.
January...	Table Bay.....	13·4	*Paralepis* sp..	2	8	14	12	136	9·7	—	—	—	This species very rare.
			Fish remains.	1	—	—	—	20	—	—	—	—	Unrecognisable.
			Crawfish (Rock Lobster)	1	2	2	3	2	1	—	—	4	Juvenile crawfish (Rock Lobster).
February..	St. Helena Bay.	14·1	Pilchard.....	5	8	31	11	142·3	3·6	310*	10*	—	Well digested.
			Maasbanker..	1	1	1	9	8·8	8·8	—	—	—	
			Fish remains.	2	—	—	—	53·8	—	—	—	—	Unrecognisable.
			Crawfish (Rock Lobster)	2	—	—	—	10·5	—	—	—	10	Juvenile crawfish (Rock Lobster).
											TOTAL.....	37	

* Calculated from available data.

Reprint from "Commerce & Industry", January, 1955

TABLE 3.

THE FOOD OF THE CAPE PENGUIN.

Month.	Locality.	Surface Temp. °C.	Food Organism in Stomach.	Number of Birds in which found	Highest Number of Organisms per Bird.	Total Number from All Birds.	Mean Total Length of Food Organisms. cm.	Total Weight of All Food Organisms. gm.	Mean Weight per Organism. gm.	Total Weight of All Organisms at Time of Eating. gm.	Mean Weight per Organism at Time of Eating. gm.	Number of Birds Shot.	Remarks.
1953. December.	St. Helena Bay.	13·3	Pilchard.....	1	53	53	8·2	217·3	4·1	217·3*	4·1*	—	Freshly eaten.
			Maasbanker..	1	1	1	7·5	8·5	8·5	8·5*	8·5*	—	Freshly eaten.
			Mackerel....	1	1	1	12	14·6	14·6	15·5*	15·5*	—	
			Fish remains.	1	—	—	—	112·1	—	—	—	1	Unrecognisable.
1954. January...	Table Bay.....	13·4	Harder.....	1	50	50	2·4	125	2·5	125*	2·5*	—	Freshly eaten.
		13·4	Crawfish (Rock Lobster)	1	7	7	2·6	—	—	10*	—	2	Juvenile crawfish (Rock Lobster).
February..	St. Helena Bay.	13·8	Pilchard.....	10	22	137	10	1,091·5	8·0	1,165*	8·5*	—	
			Maasbanker..	1	1	1	—	5·5	5·5	6*	6*	—	Little digested.
			Anchovy.....	1	14	14	9	96·5	6·9	98*	7*	—	Little digested.
			Fish remains.	3	—	—	—	38·7	—	—	—	13	Unrecognisable.
											TOTAL.....	16	

* Calculated from available data.